LINEAR MOTION COMPENSATOR

CROSS-REFERENCE TO RELATED PATENTS

[0001] Not applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable

FIELD OF THE INVENTION

[0003] The present invention relates to operator interface devices, and particularly to a linear motion compensator for use with operator interface devices and electrical switching devices that have different linear operating strokes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The features of the invention will become more clearly understood from the following detailed description of the invention read together with the drawings in which:

Figure 1 illustrate a typical operator interface and contact module assembly of the prior art.

Figures 2A and 2B illustrate in cross-section the operator interface device of Figure 1.

Figures 3A, 3B and 3C illustrate in cross-section the normal operating conditions of the contact module of Figure 1.

Figures 4A and 4B illustrate in cross-section abnormal operating conditions of the contact block of Figure 3 when the operating stroke of the input device does not match the operating stroke of the contact module.

Figure 5 illustrates in exploded view, the operator interface device and output device of Figure 1 with a stroke compensator manufactured in accordance with the present invention.

Figures 6A and 6B, illustrate in a cutaway view, a stroke compensator of the present invention installed between a typical operator interface device and a typical contact module.

Figure 7 illustrates an exploded view of one embodiment of a stroke compensator manufactured in accordance with the present invention.

Figures 8A and 8B illustrate the operation of the stroke compensator embodiment of Figure 7.

Figure 9 illustrates an exploded view of a second embodiment of the stroke adapter manufactured in accordance with the present invention.

Before one embodiment of the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of construction described herein or as illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various other ways. Further, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION OF THE DRAWINGS

[0005] Figure 1 illustrates a typical configuration wherein an input device **10**, such as an operator interface device, is assembled to an output device **14**, such as an electrical switching device or contact module, in a control panel, switchboard or similar equipment **18**. For operational simplicity, the input device **10**, as shown in Figure 1, is a simple linear movement device, such as pushbutton operator. However, for the purpose of the present invention, the input device **10** can be any input device capable of producing a linear movement or displacement, such as a rotary or lever operator that incorporates a means, such as a cam, to translate the rotary or lever movement into a

linear movement. Also for operational simplicity, the output device **14**, as shown in Figure 1, is a simple contact module.

[0006] Figures 2A and 2B illustrate the two basic operating conditions of the input device **10**, of Figure 1. It is to be understood that more complex input devices, such as rotary operators or multiple button operators, can have more than two operating conditions. The input device **10** typically includes a housing assembly **22** that can be constructed from one or more parts. The housing **22** substantially encloses and slidably supports an operating shaft **26**, having an input end **30** for receiving an external input and an output end **34** for transmitting the received external input to the output device **14**. The housing assembly **22** defines an output end **38**, which includes means (not shown) for attaching to the output device **14**, and an aperture **42** through which a linear movement of the shaft **26** can be transferred to the output device **14**. The operating shaft **26** is normally biased to a first or normal position, as shown in Figure 2A, by means of a spring **46** or similar biasing device. In response to the external input, the operating shaft **26** moves linearly within the housing assembly **22**, to a second or activated position adjacent the output end **38**, as shown in Figure 2B. When the input device **10** is in the second (activated) position, the output end **38** of the operating shaft **26** will have moved a particular linear distance or stroke $\mathbf{D_1}$ from its first position. Typically the stroke $\mathbf{D_1}$ is fixed by the internal construction of the input device **10** and can not be altered. In a typical pushbutton device, the operating shaft **26** normally returns to its first position as soon as the external input is removed. However, some input devices **10** have a latching feature that is activated when the operating shaft **26** is moved into its second position. This latching feature maintains the operating shaft **26** in its second position until some particular manipulation of the input device **10** releases the latch and allows the operating shaft **26** to return to its first position. Therefore, proper operation of such input devices **10** requires that the output end **34** of the operating shaft **26** be capable of moving the full particular linear distance $\mathbf{D_1}$.

[0007] Figures 3A, 3B and 3C illustrate the three basic operating conditions of the output device **14** of Figure 1. The output device **14**, a contact module, includes a

housing assembly **50**, which partially encloses and supports a linearly movable operating shaft **54**, a first pair of stationary electrical contacts **58** and **62** and a second pair of stationary electrical contacts **66** and **70**. The operating shaft **54** has an operating end **74**, which extends outwardly from the housing assembly **50** through an aperture **78** defined in a first end **82** of the housing assembly **50**. The first end **82** is configured for attachment to the operating end **38** of the input device **10**, such that the operating end **74** of operating shaft **54** can engage the operating end **34** of the input device operating shaft **26**, through the aperture **42**. The operating shaft **54** supports an electrically conductive bridge **86** having a pair of bridging contacts **90** at each end. In the first operating condition, the operating shaft **54** and its operating end **74** are normally biased to a first position, as shown in Figure 3A, by a spring **94**, or similar biasing device. In this first position, the bridging contacts **90** engage the first pair of stationary contacts, **58** and **62**, thereby completing an electrical path between the first pair of stationary contacts, **58** and **62**, and defining them as normally closed (NC) contacts. The second pair of stationary contacts, **66** and **70**, are not engaged by the bridging contacts **90** and are therefore normally open (NO) contacts. The biasing means **94** provides sufficient force to slightly bow the bridge **86**, thereby ensuring a good electrical connection between the bridging contacts **90** and first pair of stationary contacts **58** and **62**. In the second operating condition, as shown in Figure 3B, the operating end **74** of operating shaft **54** has been displaced from its first position, by a particular linear distance or stroke $\mathbf{D_2}$, to a second position adjacent to, or coincident with, the first end **82** of housing assembly **50**. In this second position, the bridging contacts **90** have disengaged from the first pair of stationary contacts, **58** and **62**, thereby opening the electrical path between them and have engaged the second pair of stationary contacts, **66** and **70**, thereby completing an electrical path between them. The displacement of the operating shaft **54** by the particular linear distance $\mathbf{D_2}$ provides sufficient force to slightly bow the bridge **86**, thereby ensuring a good electrical connection between the bridging contacts **90** and second pair of stationary contacts **66** and **70**. In the third operating condition, the operating end **74** of the operating shaft **54** has been displaced approximately one half of the stroke $\mathbf{D_2}$ (shown as $\mathbf{D_2/2}$). Therefore, neither of the first

or second pairs of stationary contacts, **58** and **62** or **66** and **70**, respectively, has a completed electrical path. This condition is not usually provided by simple pushbutton type input devices **10**, but is commonly supported by rotary operable input devices **10**. From the description of these operations it can be seen that the stroke $\mathbf{D_1}$ of the input device **10** must be equal, within operating tolerances, to the stroke $\mathbf{D_2}$ of the output device **14** for proper operation of both devices. This is generally not a problem when input devices **10** and output devices **14** are selected from the same product line, series or manufacturer. However, situations can arise when it is either necessary or desirable to mate an input device **10** from one product line, series or manufacturer with an output device **14** from another product line, series or manufacturer.

[0008] Figures 4A and 4B illustrate two of a number of situations which can occur when the operating parts of an input device **10** are not compatible with the operating parts of the output device **14** to which it will be attached. The illustrated conditions will be used in explaining the operation of the invention. As shown in Figures 4A and 4B, the operating end **34** of the input device operating shaft **26** is not properly position to engage the operating end **74** of the output device operating shaft **54**, when both devices are in the first or normal position and the stroke $\mathbf{D_1}$ of the input device operating shaft **26** is less than the stroke $\mathbf{D_2}$ of the output device operating shaft **54**. In this example, the operating end **34** of shaft **26** is positioned to close to the operating end **38** of housing assembly **22**. Therefore, the operating shaft **54** of the output device **14** is partially depressed and can not be moved to its first position (shown in dashed lines) by biasing spring **94**. This condition does not permit the bridging contacts **90** to engage the first pair of stationary contacts, **58** and **62,** when the input device **10** is in its first position. Further, since stroke $\mathbf{D_1}$ is less than stroke $\mathbf{D_2}$, the input device **10** can not properly place the operating shaft **54** of the output device **14** in its second or activated position, as shown in Figure 4B. However, these conditions and others can be corrected by placing a stroke compensator, as disclosed herein, between the input device **10** and output device **14**.

[0009] Figure 5 illustrates an exploded view of the input device **10**, output device **14** and one embodiment of a stroke compensator **98**, manufactured in accordance with the present invention, intermediate the input and output devices, **10** and **14**, respectively. The stroke compensator **98** includes a housing **102** which has a first end **106** adapted for connecting to the input device **10** and a second end **110** adapted for connecting to the output device **14**.

[0010] Figures 6A and 6B, illustrate in cross-section, the assembled input device **10**, stroke compensator **98** and output device **14** of Figure 5.

[0011] Figure 7 illustrates in exploded view the stroke compensator **98** of Figures 6A and 6B. The housing **102** substantially encloses and moveably supports at least one compensator cam **114** and at least one output plate **118**. The compensator cam **114** is pivotably supported by the housing **102** and the output plate **118** is slidably supported by the housing **102**. The compensator cam **114** includes a pivot pin **122**, an input round **126** and an output round **130**. The pivot pin **122** is received in a pocket **134**, intergrally formed in the housing **102**, for pivotal movement therein. The input round **126** slidably engages the output end **34** of the operating shaft **26**, as the input device **10** is operated. This slidable engagement between the output end **34** of the operating shaft **26** and the input round **126** causes the compensator cam **114** to pivot about its pivot pin **122**, from an unactivated or first position as shown in Figure 8a to an activated or second position as shown in Figure 8B. The output plate **118** has a flat surface **138**, which is slidably engaged by the output round **130** of the compensator cam **114**. The input and output rounds, **126** and **130**, respectively, define a radius suitable for slidable engagement with the output end **34** of operating shaft **26** and the flat surface **138** of the output plate **118**. The output plate **118** also includes two generally parallel slides **142**, each extending outwardly from, and being spaced apart by the flat surface **138**. The slides **142** each have an outside surface **146**, which defines an outwardly extending ridge **150**. The ridges **150** are slidably received in slots **154** defined on opposed inside surfaces **158** of the housing **102**. The ridges **150** maintain a generally parallel relationship between the flat surface **138** and the second end **110** of housing

102, as the output plate **118** moves linearly inside housing **102** in response to pivotal movement of the compensator cam **114** between its first and second positions. As the compensator cam **114** pivots about its pivot pin **122**, the output round **130** causes the output plate **118** to slidably move toward the second end **110** of the housing **102**. The second end **110** of the housing **102** defines at least one aperture **162** for receiving the operating shaft **54** of the output device **14**. An output surface **166** of the output plate **118** engages the operating end **74** of the operating shaft **54** of output device **14**. As the compensator cam **114** is rotated between its first and second positions, in response to linear movement of the operating shaft **26** of input device **10** between its first and second positions, the output plate **118** causes the operating shaft **54** of the output device **14** to be moved linearly between its first and second positions.

[0012] Referring now to Figures 8A and 8B, the operation of the compensator cam **114** will be explained in detail. The centers **A**, **B** and **C**, of the pivot pin **122**, input round **126** and output round **130**, respectively, of the compensator cam **114** form a triangle **170**, shown in dashed lines. The length of leg **ab** of triangle **170** is selected such that the input round **126** can move vertically (linearly) the known or measured stroke distance $\mathbf{D_1}$ of the input device **10**, without disengaging from the output end **34** of operating shaft **26**, as the compensator cam **114** is rotated between its first and second positions. The length of leg **ac** of triangle **170** is selected such that the output round **130** can move vertically (linearly) the known or measured stroke distance $\mathbf{D_2}$, required for properly operating the output device **14**, without disengaging the flat surface **138** of output plate **118**, as the compensator cam **114** is rotated between its first and second positions. Because of friction between sliding parts, the length of leg **ac** should also be selected such that the angle between leg **bc** and the flat surface **138** of operating plate **118** does not significantly approach 90° as the compensator cam **114** is rotated to its second position. This angle is related to the coefficient of friction of the materials of the compensator cam **114** and the operating plate **118**, or other component with which the output round **130** is slidably engaged. Generally, when the angle between leg **bc** of triangle **170** and the flat surface **138** of the operating plate **118** exceeds 70°, the possibility of a condition in which the compensator cam **114** does not return to its first

position increases. It is to be understood that limitations in the physical size of the housing **102** can restrict the placement of the pivot pockets **134** and the lengths of the legs **ab**, **ac** and **bc** of triangle **170**. It is also to be understood that the three dimensional physical shape of the compensating cam **114** can be altered to accommodate various configurations and restrictions of the housing **102** as long as a triangular configuration between the pivot pin **122**, input round **126** and output round **130** is maintained. In some applications the operating plate **118** is not required, therefore the operating round **130** would directly engage the operating end **74** of the output device operating shaft **54** in generally the same manner as the input round **126** engages the operating end **34** of the input device operating shaft **26**.

[0013] Figure 9 is an exploded view illustrating the stroke compensator housing **102** and a second embodiment of the invention. In this embodiment, a compensating screw **174**, an input nut **178** and an output nut **182** are employed. For the purpose of this discussion the term "threads" will be defined as any combination of conventional screw threads or grooves and ribs, ramps, nubs or similar projections, which can be configured to provide a spiral rotation between the compensating screw **174** and the input nut **178** or output nut **182**. The compensating screw **174** has an input end **186**, which threadably receives the input nut **178**, an output end **190**, which threadably receives the output nut **182** and a central flange **194**. The central flange **194** is captivated in a bearing pocket **198** formed in the housing **102**. The bearing pocket **198** permits the compensating screw **174** to rotate within the housing **102**, but prohibits linear movement. The input and output nuts, **178** and **182**, respectively, each have ridges **202**, which are slidably received in groves **106** formed in the housing **102**. The ridges **202** permit linear movement within the housing **102**, but prohibit rotational movement with respect to the housing **102**.

[0014] The number of threads per inch or rate of twist of both the input end **186** and the output end **190** of the compensating screw **174** is such that a linear motion applied to either the input nut **178** or the output nut **182** will cause the compensating screw **174** to rotate easily about its axis. The rate of twist of the threads **210** of the input

end **186** and its associated input nut **178** are selected such that the compensating screw **174** will be rotated a particular angle θ when a linear motion equal to stroke $\mathbf{D_1}$ of the input device **10** is applied to an input end **218** of the input nut **178**. The rate of twist of the threads **214** of the output end **190** and its associated output nut **182** are selected such that an output end **222** of the output nut **182** will move a linear distance equal to stroke $\mathbf{D_2}$ of the output device **14** in response to the compensating screw **174** rotating the particular angle θ. The input end **218** of the input nut **178** is configured for engaging the output end **34** of the input device operating shaft **26** and the output end **222** of the output nut **182** is configured for engaging the input end **74** of the output device operating shaft **54** through apertures **162** provided in the housing **102**.